National Aeronautics and
Space Administration

Glenn Research Center
Exploration Systems

Explore. Discover. Understand.

Solid-State Personal Dosimetry
PI: John Wrbanek

Mission Need

- Radiation exposure to personnel is potentially a significant health and operational issue.
- Monitoring of radiation conditions during EVA is limited to post-mission, accumulative information provided by dosimeter badges.
- Active personal dosimeter for Low Earth Orbit (LEO) EVA use is specifically recommended by JSC's Radiation Dosimetry Working Group (2003).
- National Council on Radiation Protection and Measurements (2002) recommends personal radiation monitoring for real-time dose rate & integrate dose in LEO.
- Compared to the current LEO missions, the expeditions to the Moon and Mars will place crews at a significantly increased risk of hazardous radiation exposure.

Technology Development Challenges for NASA Missions

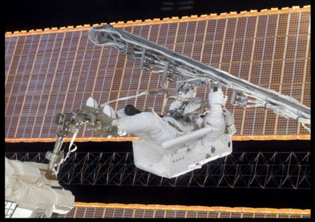
- Real-time feedback dosimeter information regarding astronaut conditions is currently not available. It would improve the safety of the astronaut and provide an alert of conditions which could affect supporting systems.
- Real-time dosimeters based on silicon electronics could provide real-time information but silicon lacks the desired sensitivity and is itself affected by radiation, decreasing the effectiveness of this technology.
- Improvements in the basic dosimeter design would provide a valuable tool to improve astronaut safety and provide better awareness of the external situation.

Goal

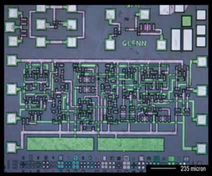
- Leverage significant experience in silicon carbide (SiC) technology to provide reliable real-time dosimetry by replacing the silicon with a significantly more rad-hard SiC semiconductor technology with improved sensitivity and detection capability.
- Apply unique, patented NASA technology improving the quality of SiC semiconductors.
- Leverage ongoing activities with the NASA Low Emissions Alternative Power (LEAP) Projectwhich will provide silicon diodes and scintillation detectors.

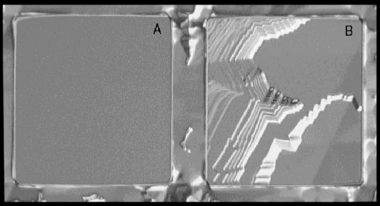
Description

- NASA GRC has been leading the world in the development of SiC semiconductor technology. In particular, NASA GRC produces semiconductor surfaces (atomically flat) of much higher quality than commercially available. These surfaces have demonstrated advantages over standard materials for other sensor applications.
- The task will first validate basic SiC approach using standard SiC devices with crystal defects and non-flat surfaces and compare with compact scintillation detectors in conjunction with the NASA LEAP project.
- Based on trial results and requirement needs determined by AEVA, move to demonstrating the use of defect-free atomically flat SiC to further improve detection capability.
- Long-term Objective: Provide a wearable, electronic dosimetry system which would not be adversely affected by radiation with improved sensitivity and detection capability for real-time monitoring of EVA conditions.

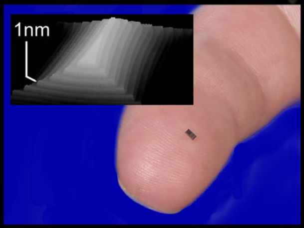


In future EVA missions, real-time dosimetry will be necessary for long exposure missions. Si-based semiconductor technology is affected by radiation; SiC is rad-hard.

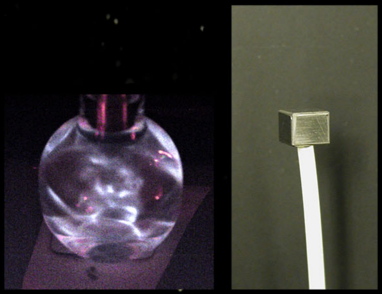




Examples of NASA GRC SiC Fabrication: Atomically Flat and Standard SiC Surfaces, and SiC circuit



2004 R&D 100 Award as one of the 100 most Significant Inventions of the Year. SiC Growth Technology for Nanoscale Measurement Standards



Radiation Detector Development: The NASA LEAP project is attempting to verify claims of nuclear energy in sonoluminescence using fiber optic thin film scintillation detectors fabricated at NASA GRC

Radiation and Micrometeoroid Mitigation Technology Focus Group

Breakout Session One – Part 1
Funded/Available Applied Technologies

DATA SHEET

Tuesday, 26 July 2005

Breakout Group (Please check one)

Personal Protection – Suit	EVA Equipment Protection	Storm Shelter Protection	Micrometeoroid Protection
X			

General Information

- Technology Title:
  Active Personal Radiation Detection System for AEVA

- Developer / Researcher:
  John Wrbanek, Gus Fralick, Susan Wrbanek, LiangYu Chen, Phillip Neudeck

- Description/Application (How does it apply?):
  The active personal radiation detection system is to provide real-time local radiation exposure information during EVA. Should undue exposure occur, knowledge of the dynamic intensity conditions during the exposure will allow more precise diagnostic assessment of the potential health risk to the exposed individual.

- Describe the technology's application for a particular mission – describe all that may be appropriate:

  - ISS/CEV – real-time radiation information during EVA sorties

  - Lunar Sorties – real-time radiation information during EVA sorties

  - Lunar Outpost – real-time radiation information during EVA sorties

  - Mars – real-time radiation information during EVA sorties

Impact/Advantages

- What are the potential advantages of the technology and/or approach for NASA?

    - Performance (increased sensitivity, ballistic rating, type of radiation, energy, etc)
      New system will be more sensitive to a wider energy range of radiation than current detectors.
    - Space Constraints ((i.e. low power, reduced mass, crew time, durability, cost, system integration, etc.)
      Improved diodes are physically robust for high sensitivity detection and not as susceptible to radiation damage as current diodes. Polymer scintillators are also physically robust, have low mass for large area coverage, flexible to suit contour, and do not require high voltage distributed about the suit.

- Indicate the degree of potential applicability of the technology toward meeting each Radiation/Micrometeoroid objective:

Objectives: *Please check the appropriate objective and the degree of applicability.*

1.___ Minimize radiation exposure to crewmembers during EVA.
___Low___Med_x__High

2.___ Minimize reliability/performance impacts on electrical/electronic systems and other instrumentation.
____Low_x_Med___High

3.___ Minimize reliability/performance impacts on EVA systems due to materials degradation.
___Low_x__Med___High

4.___ Minimize reliability/performance impacts on information and data systems.
___Low_x__Med___High

5.___ Maximize accuracy and reliability of radiation monitoring devices for human subjects.
___Low___Med_x__High

6.___ Minimize reliability/performance impacts of micro meteoroids on EVA systems
*_x__**Low___Med___High***

Developmental Profile

- Current TRL:2-3 (Research to prove feasibility: Technology concept formulated, critical function proof-of-concept in development)

- Estimate the year the candidate technology will mature to TRL 6: 2008

- Describe the major developmental hurdles/issues and/or identify the major milestones: Developing associated electronics and producing low defect materials in quantity are required for the successful application of the improved diodes, and optimizing the efficiency for radiation field are required for successful application of scintillators.

Supporting Vehicle/Infrastructure Needs and Assumptions:

- Describe other significant system dependencies or operating assumptions (power and resource availability to include crew time, systems compatibility, etc):

  System maintenance will require less than 10 minutes per week crew time, and the system power will be provided/recharged by suit.

Collaborations

- Identify Potential Leveraging or Collaborative Activities, Vendors:

  NASA GRC produces semiconductor surfaces (atomically flat) of much higher quality than commercially available that can be used for radiation detection. These surfaces have demonstrated advantages over standard materials for other sensor applications, and are being developed under Aeronautics Mission funding. NASA GRC is also attempting to verify claims of nuclear energy in sonoluminescence using thin film-coated scintillation detectors fabricated at NASA GRC as part of the LEAP project. Potential exists outside of NASA for improved real-time monitoring of radiation treatment for patients and increased safety for hospital personnel.